

Elementary Semiconductor Device Physics

Understanding Energy Band Formation
Using Circuit Theory

Kazuya Masui and
Shuhei Amakawa



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Elementary Semiconductor Physics

Edward S. Yang



Elementary Semiconductor Physics:

Elementary Semiconductor Physics Hubert Charles Wright, 1979

Elementary Semiconductor Device Physics

Kazuya Masu, Shuhei Amakawa, 2025 This book by two leading experts on semiconductor fabrication processes adopts an untraditional approach to introducing semiconductor devices to beginners The authors use circuit theory to provide a digestible explanation of energy band theory and understanding of energy band diagrams After briefly summarizing the basics of semiconductors the authors describe semiconductor devices from a circuit theoretic point of view making the book especially suitable for circuit design students and engineers Further to the emphasis on the circuit perspective the book then uses circuit theory to introduce readers to the famously indigestible energy bands of crystalline solids Additionally the book explains how to read physics from energy band diagrams of semiconductor devices in great detail The key to appreciating the real power of energy band diagrams is shown to lie in the understanding of the concept of the quasi Fermi levels introduced in 1949 by William Shockley but remaining elusive to date and therefore often omitted from energy band diagrams To rectify this some of the energy band diagrams presented in this book complete with quasi Fermi levels were drawn using a device simulator a k a technology computer aided design TCAD offering quantitative information about device physics The book could therefore also serve as a hands on course text in TCAD drawn band diagram reading Because no prior exposure to quantum mechanics is required and the book does not attempt to teach it this book is ideal for students in various disciplines who may or may not be specializing in semiconductor devices The numerous practical examples of reading TCAD based energy band diagrams are also invaluable to practicing semiconductor device engineers

Basic Semiconductor Physics

Chihiro Hamaguchi, 2009-12-09 When the first edition of Basic Semiconductor Physics was published in 2001 there were already many books review papers and scientific journals dealing with various aspects of semiconductor physics Since many of them were dealing with special aspects of newly observed phenomena or with very fundamental physics it was very difficult to understand the advanced physics of semiconductors without the detailed knowledge of semiconductor physics For this purpose the author published the first edition for the readers who are involved with semiconductor research and development Basic Semiconductor Physics deals with details of energy band structures effective mass equation and k p perturbation and then describes very important phenomena in semiconductors such as optical transport magnetoresistance and quantum phenomena Some of my friends wrote to me that the textbook is not only basic but advanced and that the title of the book does not reflect the contents However I am still convinced that the title is appropriate because the advanced physics of semiconductor may be understood with the knowledge of the fundamental physics In addition new and advanced phenomena served in semiconductors at an early time are becoming well known and thus classified in basic physics After the publication of the first edition many typographical errors have been pointed out and the corrected version was published in 2006 The publisher and my friends persuade me to revise the book adding new chapters keeping the subject at the appropriate level

Theory of Electron Transport in Semiconductors Carlo Jacoboni, 2010-09-05 This book originated out of a desire to provide students with an instrument which might lead them from knowledge of elementary classical and quantum physics to modern theoretical techniques for the analysis of electron transport in semiconductors. The book is basically a textbook for students of physics, material science and electronics. Rather than a monograph on detailed advanced research in a specific area, it intends to introduce the reader to the fascinating field of electron dynamics in semiconductors, a field that through its applications to electronics greatly contributed to the transformation of all our lives in the second half of the twentieth century and continues to provide surprises and new challenges. The field is so extensive that it has been necessary to leave aside many subjects while others could be dealt with only in terms of their basic principles. The book is divided into five major parts. Part I moves from a survey of the fundamentals of classical and quantum physics to a brief review of basic semiconductor physics. Its purpose is to establish a common platform of language and symbols and to make the entire treatment as far as possible self-contained. Parts II and III respectively develop transport theory in bulk semiconductors in semiclassical and quantum frames. Part IV is devoted to semiconductor structures including devices and mesoscopic coherent systems. Finally Part V develops the basic theoretical tools of transport theory within the modern nonequilibrium Green function formulation starting from an introduction to second quantization formalism.

Microwave Semiconductor Devices Sigfrid Yngvesson, 2012-12-06 We have reached the double conclusion that invention is choice and that this choice is imperatively governed by the sense of scientific beauty. Hadamard 1945 Princeton University Press by permission. The great majority of all sources and amplifiers of microwave energy and all devices for receiving or detecting microwaves use a semiconductor active element. The development of microwave semiconductor devices described in this book has proceeded from the simpler two terminal devices such as GUNN or IMPATT devices which originated in the 1960s to the sophisticated monolithic circuit MESFET three terminal active elements of the 1980s and 1990s. The microwave field has experienced a renaissance in electrical engineering departments in the last few years and much of this growth has been associated with microwave semiconductor devices. The University of Massachusetts has recently developed a well recognized program in microwave engineering. Much of the momentum for this program has been provided by interaction with industrial companies and the influx of a large number of industry supported students. This program had a need for a course in microwave semiconductor devices which covered the physical aspects as well as the aspects of interest to the engineer who incorporates such devices in his designs. It was also felt that it would be important to introduce the most recently developed devices HFETs HBTs and other advanced devices as early as possible.

A History of the World Semiconductor Industry Peter Robin Morris, 1990 Development of the thermionic valve. Historical survey of early research in semiconductors. Development of the transistor. Major technical processes used in semiconductor device fabrication. Review of major factors affecting the growth of the United States semiconductor industry. Review of the factors affecting the growth of the Japanese and South Korean semiconductor

industries Review of the European semiconductor industry *Elementary treatise on physics, experimental and applied, tr. and ed. by E. Atkinson* Adolphe Ganot, 1893 **Nonlinear Dynamics in Solids** Harry Thomas, 2012-12-06 This volume contains the notes of lectures given at the school on Nonlinear Dynamics in Solids held at the Physikzentrum Bad Honnef 26 October 1989 under the patronage of the Deutsche Physikalische Gesellschaft Nonlinear dynamics has become a highly active research area owing to many interesting developments during the last three decades in the theoretical analysis of dynamical processes in both Hamiltonian and dissipative systems Research has been focused on a variety of problems such as the characteristics of regular and chaotic motion in Hamiltonian dynamics the problem of quantum chaos the formation and properties of solitary spatio-temporal structures the occurrence of strange attractors in dissipative systems and the bifurcation scenarios leading to complex time behaviour Until recently predictions of the theory have been tested predominantly on instabilities in hydrodynamic systems where many interesting experiments have provided valuable input and have led to a fruitful interaction between experiment and theory Fluid systems are certainly good candidates for performing clean experiments free from disturbing influences with fluids compared to solids it is simpler to prepare good samples the relevant length and time scales are in easily accessible ranges and it is possible to do measurements inside the fluid because it can be filled in after the construction of the apparatus Further the theory describing the macroscopic dynamics of fluids is well established and contains only very few parameters all of which have well known values

High-Frequency Bipolar Transistors Michael Reisch, 2012-12-06 This book provides a rather comprehensive presentation of the physics and modeling of high frequency bipolar transistors with particular emphasis given to silicon based devices I hope it will be found useful by those who do as well as by those who intend to work in the field as it compiles and extends material presented in numerous publications in a coherent fashion I've worked on this project for years and did my best to avoid errors Despite all efforts it is possible that something has been overlooked during copy editing and proof reading If you find a mistake please let me know Michael Reisch Kempten December 2002 Notation It is intended here to use the most widely employed notation in cases where the standard textbook notation is different from the SPICE notation the latter is used In order to make formulas more readable model parameters represented in SPICE by a series of capital letters are written here as one capital letter with the rest in the form of a subscript e.g. XCJC is used here instead of the XCJC used in the SPICE input Concerning the use of lower case and capital letters the following rules are applied Time dependent large signal quantities are represented by lower case letters The variables t , v and p therefore denote time dependent current voltage and power values *Fundamentals Of Semiconductor Physics And Devices* Rolf Enderlein, 1997-02-27 This book is an introduction to the principles of semiconductor physics linking its scientific aspects with practical applications It is addressed to both readers who wish to learn semiconductor physics and those seeking to understand semiconductor devices It is particularly well suited for those who want to do both Intended as a teaching vehicle the book is written in an expository

manner aimed at conveying a deep and coherent understanding of the field. It provides clear and complete derivations of the basic concepts of modern semiconductor physics. The mathematical arguments and physical interpretations are well balanced; they are presented in a measure designed to ensure the integrity of the delivery of the subject matter in a fully comprehensible form. Experimental procedures and measured data are included as well. The reader is generally not expected to have background in quantum mechanics and solid state physics beyond the most elementary level. Nonetheless, the presentation of this book is planned to bring the student to the point of research design capability as a scientist or engineer. Moreover, it is sufficiently well endowed with detailed knowledge of the field, including recent developments bearing on submicron semiconductor structures, that the book also constitutes a valuable reference resource.

In Chapter 1, basic features of the atomic structures, chemical nature, and the macroscopic properties of semiconductors are discussed. The band structure of ideal semiconductor crystals is treated in Chapter 2, together with the underlying one-electron picture and other fundamental concepts. Chapter 2 also provides the requisite background of the tight-binding method and the $k \cdot p$ method, which are later used extensively. The electron states of shallow and deep centers, clean semiconductor surfaces, quantum wells, and superlattices, as well as the effects of external electric and magnetic fields, are treated in Chapter 3. The one- or multi-band effective mass theory is used wherever this method is applicable. A summary of group theory for application in semiconductor physics is given in an Appendix. Chapter 4 deals with the statistical distribution of charge carriers over the band and localized states in thermodynamic equilibrium. Non-equilibrium processes in semiconductors are treated in Chapter 5. The physics of semiconductor junctions, pn hetero-metal, and insulator is developed in Chapter 6 under conditions of thermodynamic equilibrium, and in Chapter 7 under non-equilibrium conditions. On this basis, the most important electronic and optoelectronic semiconductor devices are treated, among them uni- and bi-polar transistors, photodetectors, solar cells, and injection lasers. A summary of group theory for applications in semiconductors is given in an Appendix.

Elementary Electronic Structure Walter A. Harrison, 1999-06-01. This is a revised edition of the 1999 text on the electronic structure and properties of solids, similar in spirit to the well-known 1980 text *Electronic Structure and the Properties of Solids*. Current revisions include an added chapter on glasses and rewritten sections on spin-orbit coupling, magnetic alloys, and the actinides. The text covers covalent semiconductors, ionic insulators, simple metals, and transition metal and f-shell metal systems. It focuses on the most important aspects of each system, making what approximations are necessary in order to proceed analytically and obtain formulae for the properties. Such back-of-the-envelope formulae, which display the dependence of any property on the parameters of the system, are characteristic of Harrison's approach to electronic structure, as is his simple presentation and his providing all of the needed parameters. In spite of the diversity of systems and materials, the approach is systematic and coherent, combining the tight-binding or atomic picture with the pseudopotential or free electron picture. This provides parameters, the empty core radii, as well as the covalent energies and conceptual bases for estimating the various

properties of all of these systems Extensive tables of parameters and properties are included The book is written as a text with problems at the end of each chapter and others can readily be generated by asking for estimates of different properties or different materials than treated in the text In fact the ease of generating interesting problems reflects on the extraordinary utility and simplicity of the methods introduced Developments since the 1980 publication have made the theory simpler than before much more accurate and allowed much wider application

Elementary Treatise on Physics Experimental and Applied for the Use of Colleges and Schools Adolphe Ganot, Edmund Atkinson, 1901

Fundamentals of Solid-state Electronics Chih-Tang Sah, 1991 This is perhaps the most comprehensive undergraduate textbook on the fundamental aspects of solid state electronics It presents basic and state of the art topics on materials physics device physics and basic circuit building blocks not covered by existing textbooks on the subject Each topic is introduced with a historical background and motivations of device invention and circuit evolution Fundamental physics is rigorously discussed with minimum need of tedious algebra and advanced mathematics Another special feature is a systematic classification of fundamental mechanisms not found even in advanced texts It bridges the gap between solid state device physics covered here with what students have learnt in their first two years of study Used very successfully in a one semester introductory core course for electrical and other engineering materials science and physics junior students the second part of each chapter is also used in an advanced undergraduate course on solid state devices The inclusion of previously unavailable analyses of the basic transistor digital circuit building blocks and cells makes this an excellent reference for engineers to look up fundamental concepts and data design formulae and latest devices such as the GeSi heterostructure bipolar transistors

Elementary solid state physics : principles and applications M. Ali Omar, 2005

Fundamentals of Semiconductor Devices Edward S. Yang, 1978

Government and Science, Review of the National Science Foundation, Hearings Before the Subcommittee on Science, Research, and Development... United States. Congress. House Science and Astronautics, 1965

Soft Errors in Modern Electronic Systems Michael Nicolaidis, 2010-09-24 This book provides a comprehensive presentation of the most advanced research results and technological developments enabling understanding qualifying and mitigating the soft errors effect in advanced electronics including the fundamental physical mechanisms of radiation induced soft errors the various steps that lead to a system failure the modelling and simulation of soft error at various levels including physical electrical netlist event driven RTL and system level modelling and simulation hardware fault injection accelerated radiation testing and natural environment testing soft error oriented test structures process level device level cell level circuit level architectural level software level and system level soft error mitigation techniques The book contains a comprehensive presentation of most recent advances on understanding qualifying and mitigating the soft error effect in advanced electronic systems presented by academia and industry experts in reliability fault tolerance EDA processor SoC and system design and in particular experts from industries that have faced the soft error impact in terms of product reliability

and related business issues and were in the forefront of the countermeasures taken by these companies at multiple levels in order to mitigate the soft error effects at a cost acceptable for commercial products In a fast moving field where the impact on ground level electronics is very recent and its severity is steadily increasing at each new process node impacting one after another various industry sectors as an example the Automotive Electronics Council comes to publish qualification requirements on soft errors research and technology developments and industrial practices have evolve very fast outdated the most recent books edited at 2004

Poland Edyta Banaszekiewicz-Zygmunt, Krzysztof Olendzki, 2000 **Government and Science: Review of the National Science Foundation** United States. Congress. House. Committee on Science and Astronautics. Subcommittee on Science, Research, and Development, 1965 Committee Serial No 6 Contains appendices including summary of testimony p 839 906 and witnesses written responses to subsequent subcommittee questions p 905 1422

The Physics of Semiconductors Kevin F. Brennan, 1999-02-13 Modern fabrication techniques have made it possible to produce semiconductor devices whose dimensions are so small that quantum mechanical effects dominate their behavior This book describes the key elements of quantum mechanics statistical mechanics and solid state physics that are necessary in understanding these modern semiconductor devices The author begins with a review of elementary quantum mechanics and then describes more advanced topics such as multiple quantum wells He then disusses equilibrium and nonequilibrium statistical mechanics Following this introduction he provides a thorough treatment of solid state physics covering electron motion in periodic potentials electron phonon interaction and recombination processes The final four chapters deal exclusively with real devices such as semiconductor lasers photodiodes flat panel displays and MOSFETs The book contains many homework exercises and is suitable as a textbook for electrical engineering materials science or physics students taking courses in solid state device physics It will also be a valuable reference for practising engineers in optoelectronics and related areas

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